VII.—*Report on the* Tunicata *collected during the Cruise of H.M.S. "Triton" in the Summer of* 1882. By W. A. Herdman, D.Sc., Professor of Natural History in University College, Liverpool. (Plates XVI. to XX.)

(Read 16th July 1883.)

This collection was sent to me for examination some months ago by Mr Murray. It may be conveniently divided into two very natural groups :—

1. Ascidiacea, including the forms dredged or trawled from the bottom of the sea.
2. Thaliacea, including the free-swimming pelagic forms captured by the tow-net at or below the surface.

The small group of Ascidiacea contains no Compound Ascidians, and only two* of the four families of Ascidiæ Simplices known are represented in it. The one of these families (the Cynthiidæ) is represented by a single species only, while the other (the Ascidiidæ) contains the remaining three species, referred to the two genera *Ascidia* and *Ciona*. One of those species of Simple Ascidians (*Ascidia tritonis*) is new to science, the other three are well-known British forms.

This little collection of Ascidiacea is chiefly interesting (1) on account of the depths at which the specimens were procured, and (2) on account of the locality being one in which the Ascidian fauna had not been previously investigated. *Ascidia tritonis*, though a new species, is not in any way aberrant or strikingly peculiar, and hence, as far as the Simple Ascidians of the collection go, the region explored by the "Triton" may readily be regarded as an extension of the British fauna.

The second group—the Thaliacea—is a very considerable collection, as may be seen from the following list of the different localities. The most remarkable circumstance in regard to it is that, with the exception of two specimens of *Salpa*, the whole series is composed of one species, *Doliolum denticulatum*, of which between five and six thousand specimens were collected.

List of "Triton" Thaliacea.

1882.		
August 3rd—4th.	Surface.	*Doliolum denticulatum*, about 100 specimens, 1 small one (2 mm. long).
„ 4th.	Tow-net at a depth of 12 fathoms.	*Dol. denticulatum*, 8 specimens, in absolute alcohol.
„ 4th—5th.	Tow-net at a depth of 12 fathoms.	*Dol. denticulatum*, about 1000 specimens; and 1 specimen of *Salpa runcinata* (aggregate form).

* See "Postscript," page 114.

August 5th (Station 2). Nets at the weights and trawl, 530 fathoms. *Dol. denticulatum*, about 1000 specimens; also 6 specimens in absolute alcohol.

„ 7th. Surface. *Dol. denticulatum*, about 30 specimens.

„ 7th—8th. Surface. „ 3 specimens, in absolute alcohol.

„ 8th. Surface. „ 20 specimens.

„ 9th. Tow-nets at a depth of 100 to 150 fathoms. *Dol. denticulatum*, 60 specimens; also 20 in absolute alcohol.

„ „ Tow-nets at trawl at a depth of 327 to 430 fathoms. *Dol. denticulatum*, 20 specimens.

„ 13th—30th. Surface to 40 fathoms. *Dol. denticulatum*, 9 specimens.

„ 18th. Surface. *Dol. denticulatum*, 1 specimen; and 1 specimen of *Salpa runcinata* (solitary form).

„ 20th. Surface. *Dol. denticulatum*, 1 large and 3 small (2–3 mm. long) specimens.

„ „ Tow-net at a depth of 40 fathoms. *Dol. denticulatum*, about 50 specimens.

„ „ Tow-net at a depth of 300 fathoms. *Dol. denticulatum*, about 40 specimens.

„ „ Tow-nets with 400 fathoms of line out. *Dol. denticulatum*, 75 specimens.

„ „ Tow-nets at a depth of 400 fathoms. *Dol. denticulatum*, 12 specimens.

„ 21st. Surface. *Dol. denticulatum*, 1 specimen, stained brown.

„ „ Tow-net at a depth of 40 fathoms. *Dol. denticulatum*, about 50 specimens.

„ „ Tow-nets from surface to 400 fathoms. „ „ 80 „

„ „ „ at a depth of 600 „ „ „ 50 „

„ 22nd. Tow-nets between surface and 40 „ „ 25 specimens.

„ 22nd—23rd. Surface, at night. „ 75 „

„ 24th. Tow-nets at a depth of 40 fathoms. „ 1 specimen.

„ 28th. Surface. „ 50 specimens.

„ „ Surface down to 40 fathoms. „ about 40 specimens.

„ „ Tow-nets at a depth of 40 fathoms. „ 30 specimens.

„ 29th. Surface. *Dol. denticulatum*, 28 specimens, in osmic acid and absolute alcohol.

„ „ „ about 100 „ picric „

„ „ „ „ 180 „ osmic „

„ „ „ „ 150 „ chromic „

„ „ Tow-net at a depth of 5 to 10 fathoms. *Dol. denticulatum*, about 1200 specimens.

„ „ Tow-nets at a depth of 10 fathoms. *Dol. denticulatum*, about 150 specimens, in chromic acid.

„ „ Tow-nets at a depth of 13 fathoms. *Dol. denticulatum*, 1 specimen, in chromic acid.

„ „ Tow-nets at a depth of 12 fathoms. *Dol. denticulatum*, about 100 specimens, in picric acid.

„ „ Tow-nets at a depth of 20 fathoms. *Dol. denticulatum*, about 100 specimens.

„ 30th. „ „ 40 „ „ 200 „

„ „ Tow-nets with 400 fathoms of line out. *Dol. denticulatum*, about 130 specimens.

„ „ Tow-nets at weights (Station 12), 580 fathoms. *Dol. denticulatum*, 50 specimens.

„ 31st. Surface. *Dol. denticulatum*, 100 specimens.

„ „ Surface down to 40 fathoms. *Dol. denticulatum*, about 100 specimens, one of them small (3 mm. long).

„ „ Tow-net at trawl (Station 13), depth 570 fathoms. *Dol. denticulatum*, 20 specimens.

Also, obtained during the cruise of the "Knight Errant":—

August 10th, 1880, From a depth of 20 fathoms. *Salpa zonaria*, 10 specimens.

The localities of most of these dates, namely, 7, 7–8, 8, 9, 18, 20, 21, 29, and

30, are over the "Wyville-Thomson" ridge, 7, 7–8, 8, 9, and 30 being towards the NW. end, and 18, 20, 21, and 29 near the centre. 22 and 22–23 are situated in the "cold area" near its southern end; while 24, 28, and 31 are in the "warm area" near the SE. end of the ridge. 3–4, 4, 4–5, and 5 are between the island of Rona and the southern end of the ridge.

Order I.—ASCIDIACEA.

Family Cynthiidæ.

Polycarpa pomaria, Savigny (Pl. XVII. figs. 5 and 6).

I have referred a small specimen from Station 3 to this widely distributed and apparently highly variable species. I have not examined a sufficient number of specimens to be able to say much as to the range of variation from my own experience; but from a comparison of the descriptions of other investigators, it is obvious that this is one of those interesting forms out of which it is possible to make either one or half a dozen "species," according to the state of one's critical faculties. Traustedt* describes it as *Styela pomaria*, and gives as synonymous *Cynthia pomaria*, Sav., *C. coriacea*, Alder, *C. tuberosa*, Macgill, and *Polycarpa varians*, Heller; while Heller† suggests that *Cynthia sulcatula* and *C. granulata* of Alder may also be varieties merely.

There can be little doubt that Savigny's *Cynthia polycarpa* and *C. pomaria* are merely varieties of the one species now known as *Polycarpa pomaria*, Sav. (=*P. varians*, Heller), and *Cynthia tuberosa* of Macgillivray is certainly the same species; while Alder's *Cynthia sulcatula* and *C. granulata* may possibly be young individuals. But I cannot agree with Traustedt and Heller in regarding *Cynthia coriacea*, Alder and Hancock, as another variety. The description in Alder's Catalogue‡ states (1) that the ovaries are large and white, and line the mantle with cylindrical convolutions, and (2) that the branchial sac has about ten longitudinal folds, two important characters either of which would be sufficient evidence to exclude the species from the genus *Polycarpa*, while the second alone, if "about ten" may be taken as meaning more than eight, cuts it off even from the sub-family Styelinæ.

The Triton specimen, which is a small one (2 cm. in length, 1·6 cm. dorso-ventrally, and 1·2 cm. in thickness), was trawled at Station 3 (8th August 1882, at the NW. end of the Wyville-Thomson ridge, and north of the "warm area," bottom s. sh.) from 87 fathoms. Viewed from the side, it is rudely quadrate

* *Oversigt over de fra Danmark og dets nordlige Bilande kjendte Ascidiæ Simplices. Vidensk. Meddel, Nat. For.*, Kjöbenhavn, 1880, p. 415.

† *Untersuchungen über die Tunicaten des Adriatischen und Mittelmeeres*, Abth. iii. p. 19, Wien, 1877.

‡ Cat. Mar. Moll. Northumb. and Durham, *Trans. Tynes. Nat. Field Club*, vol. i. 1850.

rather than hemispherical in outline, the anterior end being truncated and almost as broad as the base of attachment. The most projecting point of the anterior end is placed midway between the two apertures, which are far apart, and distinctly upon the right side of the extremity (see Pl. XVII. fig. 5). Probably on account of extreme contraction, they are also sessile, rather inconspicuous, and irregularly lobed.

The test is thick, strong, and leathery; greyish-white on the outer surface, and white in section. At the posterior end it has several root-like prolongations from 1 to 1·2 cm. in length. The mantle is thick, strongly muscular, and closely united to the inner surface of the test.

The branchial sac has eight very prominent folds, four upon each side. The two dorsal folds on each side are more closely placed than the ventral ones, and the clear spaces bordering the endostyle are considerably wider than those beside the dorsal lamina. As the branchial sac of this species has never, so far as I am aware, been figured, I give a view (Pl. XVII. fig. 6) from the inside of a part showing two folds and the interspace in their natural relations, while at the right-hand side another interspace is represented as more exposed by the removal of the next fold. The sac is a very thick one, the folds being prominent, the internal longitudinal bars numerous, and the stigmata comparatively small. Occasional wider transverse vessels occur; in some places (see fig., *tr*) they alternate regularly with three smaller ones (*tr'*). Delicate membranes dividing the meshes are only present here and there (*tr''*). At the base of each fold lies a series of large meshes (*mh*), each of which I found contained about six stigmata. Heller mentions meshes with ten to twelve stigmata each; I found such only in the series adjoining the endostyle.

The simple tentacles are numerous and closely placed. The dorsal tubercle is small and nearly circular in outline, being slightly elongated laterally. The aperture is anterior, and both horns are coiled inwards.

The margin of the anus is expanded, and cleft into a number of blunt processes.

The yellow polycarps and grey endocarps are so numerous as almost completely to hide the inner surface of the mantle.

Family Ascidiidæ.

Ascidia tritonis, n. sp. (Plate XVI.).

External Appearance.—Shape ovate, flattened laterally, attached by posterior half of left side, especially towards the ventral edge; anterior end rather narrower than posterior but blunt. Dorsal edge slightly more convex than ventral. Branchial aperture terminal, sessile, wide, lobes distinct. Atrial

aperture on dorsal edge, halfway from anterior to posterior end, sessile, wide, indistinct lobed. Surface even and soft, but finely roughened all over. Colour greyish-brown.

Test soft, cartilaginous, not stiff; thin on right side, much thicker on left, especially at the area of attachment, where it increases to 1·5 cm.; smooth and glistening on inner surface; clear and transparent in section. Vessels not conspicuous.

Mantle.—Shape long and narrow; siphons long, especially atrial, which is placed nearly halfway down the dorsal edge; musculature strong on right side, almost absent on left, where the mantle is thin and membranous; sphincters moderately developed.

Branchial Sac rather delicate and not plicated. Transverse vessels alternately larger and smaller, the larger ones with broad membranes hanging from them. Internal longitudinal bars narrow, bearing large curved papillæ at the angles of the meshes. Stigmata long and narrow, usually five in each mesh.

Dorsal Lamina narrow, slightly ribbed transversely, and toothed on the margin; double for a short distance at the anterior end.

Tentacles numerous, of several sizes, some very long (up to 1·5 cm.), stout at the base.

Dorsal Tubercle small, irregularly ovate in outline, aperture anterior, horns not coiled.

Alimentary Canal not large, placed on the left side of the body about the middle. Œsophageal aperture two-thirds of the way down the dorsal edge of the branchial sac; stomach irregularly pyriform; intestine rather wide, and forming a narrow loop.

Genitalia in intestinal loop. Spermatic vesicles extending over the greater part of the intestine. Vas deferens wide and prominent, running along the posterior and dorsal side of the rectum towards the atrial aperture.

Three large specimens and one small one of this new species of *Ascidia* were obtained in the second haul of the dredge at Station 13 (31st August 1882, in the centre of the "warm area"), from a depth of 570 fathoms, bottom ooze. All of the specimens were more or less incrusted, especially upon the left side, with fragments of sponges and worm tubes; one of them had a few specimens of a small Tubularian zoophyte adhering, while the smallest individual had several specimens of *Anomia ephippium* attached to its test.

The largest specimen is 13·5 cm. in length and 8 cm. in breadth, the smallest 5 cm. in length and 3 cm. in breadth. The remaining two are 9·5 cm. and 10·5 cm. respectively in length, while both measure 6·5 cm. across at the widest point. In general shape, and especially in the position of the atrial aperture

(see Pl. XVI. fig. 1), this species shows resemblances to *Ascidia lata** and *Ascidia meridionalis*,† but it differs greatly from both these species in internal structure.

The shape of the body when the test is removed (Pl. XVI. fig. 3) is remarkable on account of its great antero-posterior elongation, and the position of the stomach and the intestine so far from the posterior end. The appearance presented by the body when seen from the left side suggests that this peculiar relation is caused by the branchial sac having extended posteriorly beyond the stomach.

The muscular pad at the base of the branchial siphon, from the lower edge of which the tentacles spring (Pl. XVI. fig. 6), is very strong. The tentacles are large, and so numerous that their bases touch.

The dorsal tubercle (Pl. XVI. fig. 6) is peculiar, inasmuch as the left horn is bifurcated; however, this is very possibly merely an individual variation.

With the exception of *Ascidia meridionalis*, obtained during the "Challenger" expedition at 600 fathoms, off the south-eastern coast of South America, the present species was found at the greatest depth from which the genus *Ascidia* has been recorded.

Ascidia virginea, O. F. Müller (Pl. XVII. figs. 3 and 4).

(=*Ascidia sordida*, Alder & Hancock, Cat. Mar. Moll. Northumb., &c.)

At first sight, and after a hasty examination, I was inclined to consider this specimen as a new species, but after a more careful investigation of its anatomy I prefer to regard it as merely an abnormally-shaped individual of *Ascidia virginea*. If this form should be found to occur with sufficient frequency it might be distinguished as variety *pedunculata*. I remember dredging a similar individual a few years ago in the Firth of Forth, but cannot now find the specimen in my collection.

The body is pyriform, shortly pedunculated, and attached by the posterior end (Pl. XVII. fig. 3); it is slightly compressed dorso-ventrally. The anterior end is narrow, but widens rapidly, especially on the right side; the widest point is reached at a little more than one-eighth of the distance from the anterior to the posterior end. The anterior half is moderately swollen, the posterior half is much narrower, and forms a short stalk. The apertures are both near the anterior end, not distant, sessile, but conspicuously lobed. The surface is rather irregular, but smooth; it is somewhat incrusted by foreign objects. The peduncle is slightly enlarged at its lower extremity to form a disc of

* Herdman on British Tunicata, *Linn. Soc. Jour.*, Zool., vol. xv. p. 277.

† Herdman, Report upon the Tunicata of the "Challenger" Expedition, part i. p. 207.

attachment. The colour is dirty grey. Length, 5 cm.; greatest breadth, 2 cm.; thickness of peduncle, 1 cm.

The test is thin, except at the top of the peduncle, where it is considerably thickened. The peduncle is solid, and formed of test alone. The vascular trunks enter the test at the top of the peduncle.

When the test is removed the body has the appearance usual in *Ascidia virginea*, and the mantle is in a normal condition, strongly muscular on the right side, but thin and weak upon the left.

The branchial sac corresponds in all respects with what I have found in other specimens of the species. It is longitudinally plicated to a slight degree, has strong internal longitudinal bars with no papillæ, and square meshes with five or six stigmata each.

The dorsal lamina is strongly ribbed transversely. The tentacles are numerous, closely packed together, and of several sizes. Those of the first order are long and slender. The dorsal tubercle is simple, and elongated antero-posteriorly. The posterior three-fourths or so is enclosed in the small peritubercular area, and the end is pointed. The aperture is anterior, and the horns are not coiled (Pl. XVII. fig. 4). *Ascidia virginea* is one of the most variable species known, in regard to the shape of the dorsal tubercle.* The present form is rather simpler and more symmetrical than usual, and is peculiar in having the posterior end pointed.

The single specimen was trawled off the Butt of Lewis, 25th August 1882, depth, 40 fathoms.

Ciona intestinalis, Linn. (Pl. XVII. figs. 1 and 2).

Sixteen specimens of this common British species were in the collection sent to me, four of them being preserved in absolute alcohol. They were all obtained by the trawl at Station 3 (8th August 1882, at the north-west end of the Wyville-Thomson ridge, and north of the "warm area," bottom s. sh.) from a depth of 87 fathoms. This is the greatest depth known to me at which this species has been found, but it is quite possible that it may have been obtained in Scandinavian seas, or in the Mediterranean at greater depths, though I have been unable to find records of such instances. The "Triton" specimens are all of fair size, and as some of them are much corrugated it is probable that they were large individuals when alive and expanded.

The tests are more colourless than is usual with shallow water specimens from our own coasts, and have almost none of that dull green tint which may generally be observed even after preservation in spirit. On the other hand,

* See Herdman, "On the 'Olfactory Tubercle' as a Specific Character in Simple Ascidians," *Proc. Roy. Phys. Soc. Edin.*, vol. vi. session cx. p. 256, 1881.

the red pigment spots at the branchial and atrial apertures and the pigment on the aggregation of glands at the opening of the vas deferens are as bright and conspicuous as is usual in the living animal. In one of the specimens preserved in absolute alcohol, which was dissected, the inner surface of the test was found to be closely ribbed longitudinally and less conspicuously so transversely. This has been caused by the test having remained attached to the mantle during the contraction of the latter, and having become impressed by the subjacent strongly developed longitudinal muscles.

The papillæ at the angles of the meshes in the branchial sac seemed larger than is usual in the species, and were certainly much larger than those represented by Heller* from a Mediterranean specimen. In some places their length equalled the space between two neighbouring internal longitudinal bars, so that when laid flat they stretched across the mesh.

I have observed considerable individual variation in the branchial sac of this species. In 1881† I noted a variability in the number of stigmata contained in each mesh, and since then I have met with several other points in which individuals differed. The specimens examined have been from various parts of the British seas—the Firth of Forth on the east; Lamlash Bay, Loch Fyne, and the Sound of Mull on the west; and Poole, Portland, and Dartmouth on the south coast. I have also specimens from the Channel Islands, the Chausey Archipelago, and the coast of Brittany, in addition to those collected by the "Triton" in the North Atlantic.

I have very rarely seen the arrangement figured by Heller‡ where the meshes are represented as being greatly elongated transversely, and occupied by two rows of extremely short stigmata. Usually the meshes are nearly square, and are divided into two areas by a delicate transverse membrane, which, however, does not generally interrupt the stigmata. This is shown at *tr'* in fig. 2, where the membrane crosses the mesh, while the stigmata extend behind. In the mesh below no transverse membrane is present, while in fig. 1 three are seen, the central one being much the strongest. This last arrangement was found to be very prevalent in the sac of the "Triton" specimen examined. In some specimens the meshes, in place of being square, are considerably elongated longitudinally—the reverse of the variation figured by Heller—and the contained stigmata are very long and narrow. In this case the meshes are always divided by from one to three transverse membranes.

The papillæ upon the internal longitudinal bars appear liable to considerable variations in their size and arrangement. In some cases they are present only at the angles of the meshes, as shown in the lower part of fig. 2, and are then all of much the same size. Where the meshes are divided there is usually a

* *Untersuchungen über die Tunicaten des adriatischen Meeres*, Abth. ii. Taf. iv. fig. 6, Wien, 1875.
† *Jour. Linn. Soc.*, Zool., vol. xv. p. 332. ‡ *Loc. cit.*

papilla placed at each point of intersection with the median or chief transverse membrane (*tr'* in the figs.) and the internal longitudinal bars. These papillæ are usually rather smaller than those at the angles of the meshes, but in some cases (as is shown in the upper part of fig. 2) the papillæ may be all of the same size. I have found the chief papillæ varying in size from a little less than one-half* the breadth of the mesh to (in the case of the "Triton" specimen) the entire breadth. In fig. 1 the papillæ have been omitted, in order that the transverse membranes might be clearly seen.

Returning to the "Triton" specimen, the margin of the anus was expanded and more deeply indented than is shown in HELLER's figure.† The oviduct was found full of ova, some of which were also discovered in the peribranchial cavity; and the pigmented glands at the aperture of the vas deferens seemed to form a larger and more conspicuous mass than usual.

ORDER II.—THALIACEA.

Both families of this order, the Doliolidæ and the Salpidæ, are represented in the collection.

Family I.—DOLIOLIDÆ.

Doliolum denticulatum, Quoy and Gaimard (Pls. XVIII., XIX., and XX.).

The five or six thousand specimens of *Doliolum* in the collection are, I was astonished to find, all one form, and this I have identified with the sexual generation of *Doliolum denticulatum*.‡ This species was first described and figured by QUOY and GAIMARD, the founders of the genus, in the zoology of the voyage of the "Astrolabe,"§ in 1835. It had been found in the Malay Archipelago near the islands of Amboyna and Vanikoro. Sixteen years later HUXLEY‖ published his observations made upon certain Tunicata during the voyage of the "Rattlesnake." In this paper very considerable additions are made to the knowledge of the structure of *Doliolum*, and the relations in

* In Heller's figure they are about one-fourth of the breadth of the mesh.

† *Loc. cit.*, Taf. v. fig. 8.

‡ As will be pointed out in the following description, there are a number of details, especially in the branchial sac, in which these "Triton" specimens differ from the accounts of *Doliolum denticulatum* given by KEFERSTEIN and EHLERS (*Zoologische Beiträge*, 1861) and by GROBBEN (*Arbeiten aus dem Zoolog. Instit. der Univ. Wien*, 1882). As, however, they agree with those authors' descriptions in the more important anatomical features, and as they could not be referred to any other known species, I prefer to consider them as a variety of *Doliolum denticulatum*. It is improbable that they are an undescribed species, since they are apparently so common in the North Atlantic. *Doliolum denticulatum* is probably rather a variable form.

§ "Voyage de découvertes de l'Astrolabe," Zoologie, T. iii. pt. 2, p. 599; Atlas, Mollusques, pl. lxxxix. figs. 25–28. Paris, 1835.

‖ "Remarks upon Appendicularia and Doliolium," &c., *Phil. Trans.* for 1851, part 2, p. 599, pl. xviii.

which the genus stands to *Salpa* and *Pyrosoma* are pointed out. Huxley's specimens had been obtained in the South Pacific between Australia and New Zealand. During the next few years Krohn,* Gegenbaur,† and Leuckart‡ worked at the Pelagic Tunicata, but their efforts, and especially those of the two former investigators, were mainly directed towards the elucidation of the remarkably complex life-history of *Doliolum*, and the additions made to the knowledge of the adult structure were comparatively few and unimportant.

Keferstein and Ehlers,§ during the winter of 1859–60, investigated several Mediterranean forms of *Doliolum*, both as regards their anatomy and life-history. As the chief subject of their observations was *Doliolum denticulatum*, it has been of great advantage to have their description and careful figures with which to compare the "Triton" specimens. No works of importance upon *Doliolum* have appeared since, with the exception of Ulianin's‖ and Grobben's¶ papers, published during the last two years. These are mainly devoted to the development and life-history, which is now almost completely cleared up. Grobben, however, treats also of the anatomy and histology, and to his memoir, as well as to that of Keferstein and Ehlers, I shall have to refer in the following description.

Commencing with the body form, most of the "Triton" specimens are of the characteristic barrel shape (see Pl. XVIII. figs. 1, 2, 3, 4, and 9), some of them (as fig. 9, which was drawn from a specimen obtained August 4–5 from 12 fathoms) being rather wider than others. Some specimens, however (see fig. 10, which represents two specimens obtained on August 5th from a depth of 530 fathoms), are very different in shape, being narrow, elongated, and almost cylindrical. At first I separated out a number of these forms, under the impression that they were a distinct species from the barrel-shaped individuals, but found afterwards, when examining their structure, that the two kinds agreed perfectly in all the details of their anatomy. Since then I have found various intermediate shapes between those shown in figs. 9 and 10, and have consequently no hesitation in considering them all as one species. As a rule, I find it is the specimens from considerable depths, and those which have been closely packed in a tube or bottle, which diverge most from the typical barrel

* "Ueber die Gattung Doliolum," &c., *Archiv für Naturgeschichte*, 1852, p. 53.

† "Ueber die Entwicklung von Doliolum," *Zeitschrift für wissensch.*, Zoologie, 1853, Bd. v. p. 13; and "Ueber die Entwicklungscyclus von Doliolum," &c., *Zeitschrift für wissensch.*, Zoologie, 1855, Bd. vii. p. 283.

‡ *Zoologische Untersuchungen*, Heft ii., "Salpen und Verwandte," Giessen, 1854.

§ *Zoologische Beiträge*, iii., "Ueber die Anatomie und Entwickelung von Doliolum," Leipzig, 1861.

‖ "Ueber die embryonale Entwicklung des Doliolum," *Zoologischer Anzeiger*, iv. No. 92, p. 472, and No. 96, p. 575, 1881; also "Zur Naturgeschichte des Doliolum," *Zoologischer Anzeiger*, v. p. 429 and p. 447, 1882.

¶ "Doliolum und sein Generationswechsel," &c., *Arbeiten aus dem Zoolog. Instit. der Univ. Wien*, &c., t. iv. h. 2, 1882.

shape, hence it is probable that the abnormal form is due either to the animal not having been killed suddenly enough or to imperfect preservation. All of the "Triton" specimens, with the exception of the five small ones mentioned in the list on page 93, are between 6 mm. and 12 mm. in length, and most of them measure 1 cm. This size is apparently much greater than that of Mediterranean specimens, as Grobben speaks of his as being about 2·5 mm., while Keferstein and Ehlers figure one 3 mm. in length.

Most of the specimens are in ordinary rectified spirit, while a few have been treated in each of the following methods:—

1. Preserved in absolute alcohol.
2. Put first into chromic acid solution and then into absolute alcohol.
3. Preserved in a saturated solution of picric acid.
4. Put first into solution of osmic acid and then into absolute alcohol.
5. Put first into solution of picric acid and then into absolute alcohol.
6. Preserved in solution of chromic acid.

These specimens were all in excellent condition for examination, and the different methods appear to give almost equally good results. Perhaps the best preparations for most histological points were obtained from the specimens preserved in chromic acid by thoroughly washing in alcohol, staining in picro-carmine, and mounting in Farrant's solution; while for some few special points the specimens preserved in osmic acid solution and absolute alcohol excelled.

The test is almost absent, being represented merely by a delicate structureless layer over the ectoderm, which covers the surface of the mantle. The mantle contains the muscular bands or hoops, which, in this form, are eight in number (m^1 to m^8 in the figs.). The first and last of these bands form sphincters for the apertures, and usually appear to terminate the body anteriorly and posteriorly, as shown in Plate XVIII. fig. 4, the delicate denticulated margins of the branchial and atrial apertures being almost invariably turned in or directed across the opening. This denticulated margin was turned out in the chromic acid specimens examined, and was more perfectly preserved than in any of the others. It is divided into twelve lobes around the branchial aperture and ten around the atrial. The muscle bands are composed of very long non-striped fibres, closely and regularly placed, as shown in Plate XVIII. fig. 6. Sometimes, as in fig. 5 (from a picric acid specimen), the fibres are thrown into undulations.

The wide branchial aperture leads into the branchial siphon, which, as there is no diaphragm and no circlet of tentacles, may be considered as extending back to the peripharyngeal band. This band, in all the specimens which I have examined, runs in most of its course between the 2nd and 3rd muscle bands, or in the 2nd intermuscular space (Pl. XVIII. fig. 11, *p.p*), and marks the anterior

end of the branchial sac, which extends back usually to between the 5th and 6th muscle bands. Grobben, however, describes and figures* the peripharyngeal band as lying in the 1st intermuscular space. Keferstein and Ehlers also represent† the branchial sac as extending anteriorly into the 1st intermuscular space, an arrangement which I have been unable to find in the "Triton" specimens.

The arrangement of the stigmata is as follows:—A series commences on each side of the median dorsal line, close behind the 3rd muscle band (see Pl. XVIII. figs. 8 and 11, *sg*), and extends posteriorly for a variable distance —usually to about the 6th muscle band. The stigmata in this series differ greatly in size among themselves. The most anterior one is very short—in fact, almost circular. The next three or four increase rapidly in length till the level of the nerve ganglion (*n.g.*) is reached, and then the increase becomes less marked. Towards the posterior end there is a slight diminution in size. Considered as a whole, the two series of stigmata diverge somewhat posteriorly, so that the space between them in the dorsal middle line is narrow in the 3rd intermuscular space, the region of the ganglion, but widens posteriorly (Pl. XVIII. fig. 11). As a result of this arrangement, when the branchial sac is seen from the side, the dorsal series of stigmata appear to slope downwards and backwards from the region of the ganglion (see Pl. XVIII. fig. 4). There is also a series of stigmata upon each side of the ventral median line. These, however, do not extend so far anteriorly as the dorsal series do. They commence behind the 4th muscle band, near the posterior extremity of the endostyle, and extend backwards, increasing in length rapidly at first, and then maintaining their size till they come to the sides of the œsophageal aperture. Here they commence to curve dorsally, and then towards each other, finally uniting in the dorsal middle line, usually near the 6th muscle band, so as to form a curve surrounding the membranous area in which the œsophageal aperture is placed (see Pl. XIX. fig. 10, *sg*).

The membranous side wall of the branchial sac is very wide anteriorly, where it extends from the endostyle almost to the ganglion dorsally. In the 4th intermuscular space it is encroached upon by the development of the ventral series of stigmata, and as it is traced posteriorly from this point, it becomes narrower and narrower, till finally it merges upon each side into the median dorsal area through the failure of the dorsal stigmata. The exact number of stigmata in the different series varies of course according to the size of the individual. In mature specimens there are usually from thirty to fifty in the dorsal row on each side, and about thirty as an average in each ventral series.

* *Loc. cit.*, p. 13, woodcut, and pl. i. fig. 1, *wb*.
† *Zoologische Beiträge*, pl. ix. figs. 1 and 2.

A glance at Plate IX. of KEFERSTEIN and EHLERS' work suggests that the specimens there figured may have been young, and the number of stigmata shown (thirteen to fifteen in the dorsal row) is just about the number present in the smallest "Triton" specimens (2 mm. long). Perhaps this may also account for the great anterior extension of the dorsal rows of stigmata which are represented as reaching in front of the 2nd muscle band, while in the "Triton" specimens they were never seen in front of the 3rd (see Pl. XVIII. figs. 8 and 11). The ventral band, containing fifteen stigmata, is shown by KEFERSTEIN and EHLERS extending to the front of the 3rd intermuscular space, while in all the specimens which I have examined, it has terminated some place in the 4th intermuscular space. GROBBEN* speaks of forty-two as the largest number of stigmata upon each side which he observed, KEFERSTEIN and EHLERS† say that the number may vary from twenty-six to forty-three, while the usual number in the "Triton" specimens was about seventy! GROBBEN also describes and figures‡ the series of stigmata as extending exactly one intermuscular space further anteriorly than I found to be the case. As they appear always to terminate posteriorly in the neighbourhood of the 6th muscle band, it is obvious that there must be a greater number of stigmata in each intermuscular space in the "Triton" specimens than in those from the Mediterranean, and a comparison of my figures on theone hand, with those of GROBBEN and of KEFERSTEIN and EHLERS on the other, shows that this is the case.

The bars separating the stigmata are covered in the usual manner with ciliated cells placed in such a position that the cilia project across the stigmata. These cells are not placed in a single row, as a surface view of the branchial sac such as that shown in fig. 2, Plate XIX. might lead one to imagine, but are placed in groups of four or five elongated cells placed closely side by side§ (see Pl. XIX. fig. 3). This arrangement can only be made out by viewing the bar upon which the cells are placed from the interior of the stigma. An osmic acid preparation showed with a Zeiss $\frac{1}{12}$-in. oil immersion objective that these cells were nucleated and nucleolated, and had a striated band upon the free edge, from which the cilia project (Pl. XIX. fig. 4). At the rounded ends of the stigmata the ciliated cells are very numerous, forming many rows. They also change their character (see Pl. XIX. fig. 2), and become cubical, spherical, or polygonal in shape.

The endostyle is always a well-marked feature in the ventral middle line of the branchial sac. It extends from midway between the 2nd and 3rd muscle bands anteriorly (Pl. XVIII. figs. 7 and 11, *en*) to somewhere in the

* *Loc. cit.*, p. 16. † *Loc. cit.*, p. 57. ‡ *Loc. cit.*, p. 16, and pl. i. fig. 1.

§ GROBBEN has figured a similar arrangement in the case of the asexual forms of the same species (*Loc. cit.*, pl. v. figs. 34, &c.).

4th intermuscular space posteriorly. KEFERSTEIN and EHLERS represent it as extending rather further anteriorly, but terminating at the 4th muscle band posteriorly; while in GROBBEN's figures it commences as in mine, but terminates in the 3rd intermuscular space. At its anterior extremity the endostyle is joined by the ventral ends of the two peripharyngeal bands (see Pl. XVIII. figs. 7 and 11), while posteriorly it is continued into a membrane with a free projecting edge which runs backwards over the heart, and then round the left hand side of the œsophageal aperture (Pl. XIX. fig. 10, *mb*). The histology of the endostyle has been minutely described by GROBBEN (*loc. cit.*).

The prebranchial zone, the region anterior to the peripharyngeal band, is covered by squamous epithelium. In osmic acid preparations the protoplasm in these cells is found to have become contracted and aggregated around the distinct nuclei, so as to present the appearance, shown in Plate XIX. fig. 6, of stellate cells united by their processes to form a network.

On the surface of the peripharyngeal band this epithelium has become modified into long fusiform cells (Pl. XIX. fig. 5) all placed with their long axes directed along the band. When not so highly magnified, or not stained properly, they give rise to the appearance shown in Plate XVIII. fig. 13. The dorsal ends of the two peripharyngeal bands meet, but at this point they are twisted round so as to form a double spiral towards the right, the left hand band performing one and a half turns, and the right a single turn only. This arrangement is shown in figs. 8, 11, and 12 on Plate XVIII., and at once suggests the form of the dorsal tubercle found in a similar position in the Ascidiacea. That organ is represented, however, in *Doliolum*, not by the curved dorsal part of the peripharyngeal band which has been described, but by the anterior end of the deeply funnel-shaped depression indicated by *n.a* in figs. 8 and 12.*

The part of the prebranchial zone which is enclosed by the dorsal spirals of the peripharyngeal band has its epithelium modified into large polygonal cells, the outlines and nuclei of which are strongly marked. In the preparation from which fig. 7 on Plate XIX. was drawn, the protoplasm in most of the cells was aggregated around the nucleus in a stellate form.

The nerve ganglion is placed in the mantle, and indicates the median dorsal line. It is small, but very distinct from its opacity. It is usually rudely cubical or nearly spherical in shape, and gives off four large nerve trunks, two at its anterior and two at its posterior angles, besides smaller nerves between. It usually lies a short distance behind the 3rd muscle band, as shown in figs. 8

* Possibly the cavity (*n.a* in the figures) represents merely the opening of the duct from the neural gland into the dorsal tubercle of the Ascidiacea, while the spirals (*d.t*, in Pl. XVIII. fig. 11) indicate the sense-organ, which I believe the dorsal tubercle to have formerly been (see *Proc. Roy. Soc. Edin.*, p. 144, 1882–83.

and 11 on Plate XVIII., but may be further back as represented by KEFERSTEIN and EHLERS in their pl. ix. fig. 1. It may advance forward, so as to touch the 3rd muscle band (see Pl. XIX. fig. 1), but is never found outside the 3rd intermuscular space.

The ganglion is very opaque, and it is difficult to make out its constitution. Fig. 8 on Plate XIX. shows its anterior end with four nerves, two large and two small, arising from it. GROBBEN * has apparently not noticed the smaller pair (Pl. XIX. fig. 8, *n'*), but he describes a median anterior nerve which I could not find in any of my specimens, unless it be the nerve shown at *n* in Plate XVIII. fig. 12, which is drawn from an individual having apparently only three anterior nerves. As in other Tunicates, where the matter has been investigated, the nerve cells are all in the outer layers of the ganglion, and the centre is formed of a mass of delicate interlacing fibres and granular matter. Fig. 12, Plate XIX., shows this arrangement well. The nerve cells are ovate, unipolar, bipolar, or multipolar, rarely the latter. They are finely granular, and have distinct nuclei and nucleoli (see Pl. XIX. fig. 13).

On the ventral surface of the ganglion there lies a dark mass which must be the neural gland, but of which I was unable to make out the structure definitely. It gives rise anteriorly to a very delicate duct which runs directly forwards to open at the prebranchial zone into the funnel-shaped depression mentioned above (see Pl. XVIII. figs. 8 and 12). This duct is wide where it emerges from below the ganglion, and its wall is formed of distinct polygonal cells (see Pl. XIX. fig. 8 *n.d*). It rapidly narrows, however, as it runs forwards, and the cell elements lose their distinctness, so that in the part immediately in front of the 3rd muscle band (Pl. XVIII. fig. 8, *n.d*) it is very difficult to make out any structure in the wall. In front of this point it again becomes more distinct, and the cells vary from fusiform to squamous in their character (Pl. XIX. fig. 9, *n.d*) up to the point where the duct joins the funnel-shaped depression.

The length of this neural duct varies with the positions of the ganglion and of the aperture in the prebranchial zone. The normal arrangement is shown in figs. 8 and 11, Plate XVIII., while in fig. 1, Plate XIX., it is abnormally short, on account of the unusual position of the ganglion. The aperture in the prebranchial zone is always placed in the median dorsal line upon the most anterior point of the spirals formed by the peripharyngeal band, and therefore in the 2nd intermuscular space. GROBBEN and also KEFERSTEIN and EHLERS figure it in the 1st intermuscular space, an arrangement which I have never seen. Although the peripharyngeal bands encroach upon the 1st intermuscular space at the two sides (see Pl. XVIII. fig. 11), they always, in the specimens which I have examined, dip posteriorly at the ventral and dorsal

* *Loc. cit.*, p. 9.

ends, and hence the anterior end of the endostyle and the dorsal spirals come to be situated in the 2nd intermuscular space.

The aperture in the prebranchial zone is small, and leads into a funnel-shaped cavity continuous with the neural duct (Pl. XIX. fig. 9). At the posterior narrower end of this cavity, the flat cells lining the duct become gradually cubical and then low columnar, and bear each a long cilium which projects into the centre of the cavity, and is directed posteriorly. This funnel-shaped cavity is apparently merely the aperture of the neural duct. I have searched in vain for any trace of a sensory apparatus. In several specimens I have succeeded in tracing one of the smaller nerves given off from the anterior end of the ganglion in its entire course forwards (see Pl. XVIII. fig. 12, *n*). It runs alongside the duct and close to it, but passes the funnel-shaped cavity upon its left side without giving off any branch, and continues its way anteriorly to supply the lobes around the branchial aperture.

The heart is situated on the ventral surface of the posterior end of the branchial sac, just between the termination of the endostyle and the œsophageal aperture and in the posterior part of the 4th intermuscular space (Pl. XIX. fig. 10, *h*). In chromic acid specimens the transverse muscle bands of the wall of the heart were well shown (see Pl. XIX. fig. 11), but each band appears to me to be composed of a large number of very fine fibres placed side by side, and not of one fibre only as supposed by Keferstein and Ehlers.*

The alimentary canal, omitting the pharynx or branchial sac, which has been already considered, consists of œsophagus, stomach, and intestine, and forms a curved tube, lying mainly in the 5th and 6th intermuscular spaces (Pl. XVIII. fig. 4).

The œsophageal aperture is placed at the posterior end of the branchial sac in the middle line, and nearer to the ventral than to the dorsal surface. It lies in the membranous area prolonged back from the region around the posterior extremity of the endostyle (Pl. XIX. fig. 10), and is surrounded laterally and dorsally by the posterior end of the ventral series of stigmata. This is a notable point, since it is usual in the Ascidiacea for the œsophageal aperture to be placed on the dorsal edge of the sac, and invariably so amongst Ascidiæ Simplices, in some of which it is placed nearer to the anterior than to the posterior end of the dorsal edge.

The œsophageal aperture is surrounded by a membranous rim, which on its left anterior edge is continued forwards to join the posterior extremity of the endostyle, while at its other end, after surrounding the aperture (see Pl. XIX. fig. 10, *mb*), it is continued as a spiral ridge into the cavity of the œsophagus. The œsophagus is short, and leads downwards and backwards to the anterior end of the large irregularly quadrangular stomach (Pl. XX. fig. 1, *st*). From

* *Loc. cit.*, p. 58.

the posterior end of this the short curved intestine emerges. The stomach lies in the 5th intermuscular space, and the intestine runs backwards till it almost or quite reaches the 7th muscle band, and then turns dorsally and to the right, and finally runs forwards to terminate in the anus placed in the 5th intermuscular space, over the stomach (Pl. XVIII. fig. 4). According to Keferstein and Ehlers the anus is situated at the posterior part of the 5th intermuscular space, or upon the sixth muscle band, while according to Grobben it lies in the 6th intermuscular space. Huxley figures it in the fifth intermuscular space. The epithelium lining the intestine is polygonal in surface view (Pl. XX. fig. 4) and very distinctly nucleated. In the wall of the stomach the cells are columnar and more darkly coloured.

Two glandular systems, which seem to be quite distinct, are found in connection with this alimentary canal. First, along the ventral surface of the stomach, especially towards the pyloric end, and more or less scattered over the first portion of the intestine, may be found masses of rather darkly coloured glandular-looking cæca (see Pl. XX. fig. 1, *gl*). These branch and apparently anastomose occasionally, forming rude networks, but the branches are short and stout, and the meshes small and irregular. No duct or opening into the alimentary canal was visible. With a higher magnification the cæca present somewhat the appearance shown in Plate XX. fig. 5—masses of cells rounded or polygonal in outline, but rarely angular, having small indistinct nuclei and granular cell-contents. These clumps of branched cæca have apparently not been noticed previously, as I find nothing in the published descriptions and figures which could represent them.

The second glandular apparatus is the system of fine clear-walled tubules ramifying over the intestine, which was first pointed out in *Doliolum* by Huxley,* and has since been more or less completely described by Leuckart, Gegenbaur, Keferstein and Ehlers, and Grobben. It has also been recently investigated by Chandelon† in *Perophora* and *Salpa*, where it has very much the same arrangement as in *Doliolum*. Chandelon comes to the conclusion that the system can be compared neither with a kidney nor a liver, but that it is probably a digestive gland of some kind.

In the specimens which I examined this system appeared generally well developed, although it was sometimes difficult to make out, owing to the opacity of the alimentary canal caused by its food contents. In Plate XX. fig. 1, *d* indicates the duct of this system, which is a clear-walled, almost transparent vessel, entering the pyloric end of the stomach. From this point it may be traced upwards and backwards (Pl. XX. fig. 1, represents a specimen

* *Phil. Trans.*, 1851.

† "Recherches sur une annexe de tube digestif des Tuniciers," *Bulletins de l'Academie Royale de Belgique*, 2me ser. t. xxxix. No. 6, 1875.

in which the intestine has been turned *ventrally* so as to expose the whole alimentary system) to about the middle of the intestine. At this point the duct divides, and its two branches run over the wall of the intestine, subdividing as they go. The twigs branch freely and sometimes anastomose (Pl. XX. fig. 3). Many of them end in short cæcal projections, and in some cases these are enlarged to form terminal knobs (see Pl. XX. fig. 3, *c*), which may contain irregularly rounded bright bodies (concretions?) similar to those described by Chandelon in *Perophora.*

The wall of the main duct is lined by regularly arranged fusiform cells placed with their long axes parallel to the length of the duct (Pl. XX. fig. 2). The tubules on the intestine are lined by flattened epithelium bulging into the lumen where the nuclei occur, and enlarged into cubical cells in the terminal knobs.

The apertures of the reproductive organs lie at the posterior end of the body behind the alimentary canal, and usually in the 6th intermuscular space. All the "Triton" specimens of *Doliolum denticulatum* examined belong to the sexual generation, Keferstein and Ehlers' "generation A," and have both male and female organs well developed.

The ovary is an ovate mass placed usually in front of the 7th muscle band (Pl. XX. fig. 7, *ov*), but occasionally behind it (Pl. XX. fig. 6, *ov*). Ova of different sizes were almost always distinctly visible in it (Pl. XX. fig. 1, *g*, and fig. 13, *ov*). It opens on its dorsal edge into the atrial cavity.

The testis, as Huxley* first correctly described, is in the form of a greatly elongated tube, usually nearly as long as the body, terminating posteriorly on the anterior face of the ovary, and extending forwards for a variable distance with rather an irregular course (Pl. XX. figs. 6, 7, &c., and Pl. XVIII. figs. 1–4). At its posterior end, where it abuts against the ovary, it turns dorsally, forming a tube which may be called the vas deferens, and opens into the atrial cavity (Pl. XX. figs. 13 and 14, *v.d.*).

The anterior end of the testis is very variable. Keferstein and Ehlers state that it may terminate any place between the 3rd and the 1st intermuscular space, and they figure it at the posterior end of the 3rd in one case and the anterior end of the 4th in another. Grobben states that it extends forward to the 4th muscle band, while Huxley figures it as reaching nearly to the 1st. In most of the specimens which I have examined the anterior end is placed close to the 2nd muscle band, as shown in Plate XX. figs. 6 and 9. No previous investigators, so far as I am aware, either describe or figure the extraordinary variability in form of this anterior end of the testis. A glance at figs. 6, 7, 8, 9, 10, and 11 on Plate XX. shows the extent of this variability. In fig. 6 the tube becomes rapidly smaller opposite the 3rd muscle band,

* *Phil. Trans.*, 1851, part ii. p. 602.

and, after a short undulating course as a very fine tubule, enlarges into a pear-shaped dilatation extending to the 2nd muscle band. In fig. 9, which is drawn on a larger scale, there are two dilatations on the narrow part of the tube, while in fig. 11 the narrow part is long and convoluted, and extends forward to the 2nd muscle band. In fig. 10 the testis reaches the 2nd muscle band without any diminution in its calibre, and then, narrowing slightly, forms a loop extending almost to the 1st band, after which it curves back towards the 2nd, and ends in a narrow filament. The two remaining cases figured are the most remarkable of all. In fig. 8 the tube narrows rapidly opposite the 3rd muscle band, and from this point forwards almost to the 1st it remains very narrow, but with two large ovate dilatations and several smaller ones upon its course. Fig. 7 shows a case where the wider tube extends to the 2nd band and then suddenly narrows, but the fine tubule, in place of running forwards, turns posteriorly, and eventually reaches the 4th muscle band after passing through several irregular dilatations. Throughout, this male system was filled with minute granular cells (Pl. XX. fig. 12), but no distinct spermatozoa could be made out.

The most remarkable feature of this "Triton" collection of Doliolidæ is, that such vast numbers should prove to be entirely one generation of the same species, and all, with a very few exceptions, of much the same size. Questions naturally arise such as, Where have they come from? Where are the asexual forms from which they have been produced? and Why are such quantities of that species found in that locality at that time? We are not yet in a position to answer any of these questions fully. Mr Murray tells me that when captured, they were all drifting from the south-west to the north-east. This would carry them from the "warm area" across the "Wyville-Thomson" ridge into the "cold area," but what part of the Atlantic they came from, or how far north they are carried, is not known. Mr Murray states that "they were abundant during the whole time of the cruise, except when we touched upon the Faroe bank water." As far as I can judge from the numbers of specimens in the tubes collected on the different days, the configuration of the bottom and the division of the region explored into "warm" and "cold" areas has no effect whatever upon the abundance of the Doliolidæ. There are large quantities of specimens in the collection from the 3rd to the 5th August, halfway between Rona Island and the south-east end of the ridge; on the 29th August, over the centre of the ridge; on the 28th and 31st August, in the "warm area;" and on 20th to 23rd August, in the "cold area." The region from which the smallest numbers have been brought back are those explored on the 7th to the 9th August at the north-west extremity of the ridge.

Mr Murray has kindly supplied me with the following extracts from his

journal, which bear upon the abundance of the Doliolidæ at different times, and relatively to other surface forms :—

"*August* 5, 1882.—Doliolums were quite as abundant to-day as yesterday; they appeared to be chiefly about 10 fathoms beneath the surface. Diatoms in the stomach as usual. The immense mass of these in this portion of the sea at this time is very astonishing.

"The last year (1880), in the "Knight Errant," the most characteristic thing in the surface gatherings was the enormous multitude of Acanthometræ, and now these are almost absent.

"*August* 7.—There was quite a change this morning in reference to the general character of the tow-net gatherings. The Doliolums had quite disappeared, and Acanthometræ were now very abundant, and the most characteristic animals.

"In the afternoon, after we had moved south from the Faroe Bank, we got again the same surface animals as yesterday and the day before, viz., vast numbers of Doliolums, some Medusæ, larvæ of Medusæ or other Cœlenterates and Copepods.

"This is a somewhat remarkable change, and would perhaps indicate a current of water from a different source than the more northern water of this morning.

"*August* 18.—The Doliolums also were observed to be phosphorescent, emitting electric-like discharges which were divided like forked-lightning, and appeared to me to follow the direction of the nervous cords or filaments . . . . Doliolums and Actiniæ were again abundant throughout the day, sometimes in enormous abundance.

"*August* 24.—There are no Doliolums, and only a few Arachnactis in the nets this morning, from about 30 or 40 fathoms. . . . . Doliolums were got in some hauls at a depth of 10 fathoms during the day.

"*August* 29.—There were a large number of Doliolums on the surface during the day, indeed they masked all the other things in most of the hauls. In general, the Doliolums were most abundant about 5 or 6 fathoms beneath the surface.

"*August* 30.—During the day, in the tow-nets at and near the surface, Doliolums and Arachnactis were most abundant, filling the nets each time.

"It is remarkable that in the tow-nets, at the weights, there were not over one or two Doliolums, but many Copepods, apparently Arctic forms, &c.

"In summary, Doliolums most abundant, masking all the other things for weeks. At times the Doliolums appeared to be in vast banks, where they were very numerous; between these banks there were always a few stragglers. J. M."

Family II.—Salpidæ.

During the "Triton" expedition only two specimens of *Salpa* were obtained, but curiously enough these show the two conditions—solitary and aggregated—of the same species, *Salpa runcinata*. In August 1880, during the cruise of the "Knight Errant" in the same neighbourhood, some large specimens of *Salpa zonaria* were the only Tunicata captured.

Salpa runcinata, Chamisso.

1. Solitary form. One specimen, measuring 2·2 cm. in length, was obtained on the surface on the 18th August 1882.

2. Aggregated form. A single member of a chain was captured in the tow-net at a depth of 12 fathoms, 4th–5th August 1882.

This is the *Salpa fusiformis* of Cuvier, and has the body prolonged both anteriorly and posteriorly beyond the branchial and atrial apertures into long tapering appendages. The body proper measures 1·5 cm. in length and 1 cm. in breadth, while the anterior appendage extends beyond the branchial aperture for 1·4 cm., and the posterior appendage beyond the atrial aperture for 1·7 cm.

Salpa runcinata is a well known Scandinavian form, and has been obtained in British seas before now. Early in the present century, Dr John Macculloch described (*Western Isles*,* vol. ii. p. 187) and figured, under the name of *Salpa moniliformis*, a form which may have been the aggregate condition of *S. runcinata*. He found the chains occurring in abundance in autumn in the harbours of Canna and Campbellton. In the spring of 1821 Dr Fleming found many chains a foot and more in length upon the Caithness coast; and about thirty years later Professor Edward Forbes identified with *Salpa runcinata*, both solitary and aggregated, some specimens captured by Lieutenant Thomas, R.N., in the Orkney Seas. In 1868 Professor M'Intosh† came upon vast quantities of both the solitary and the chain form of *Salpa runcinata* upon the east shores of North Uist, in company with both forms of *Salpa spinosa*, Otto, a species which Forbes had predicted would probably be found in the Hebrides.

Salpa zonaria, Chamisso.

Ten specimens of this form were obtained in the tow-net, at a depth of 20 fathoms, on 10th August 1880, during the cruise of the "KnightErrant." The specimens are well preserved, and are all about 4 cm. in length.

* See Forbes and Hanley, *History of the British Mollusca*, vol. i. p. 50, 1853.

† See *Jour. Linn. Soc.*, Zool., vol. ix. p. 41.

Postscript.

Since the above was written, I have received from Mr Murray another "Triton" specimen. This necessitates the following addition to my report which should be inserted between "Ascidiacea" and "Family Cynthiidæ," near the top of page 95 :—

Family Molgulidæ.

Eugyra glutinans, Möller.

A single specimen of this widely distributed species was obtained in the second haul of the trawl on the 22nd August 1882, at Station 8 (in the "cold area," near the S.E. end of the "Wyville-Thomson" ridge), from a depth of 640 fathoms. This is a greater depth than any from which Molgulidæ were obtained during the "Challenger" Expedition.

The incrusting sand is very fine, and the bare area around the apertures is conspicuous. In the branchial sac there are usually about eight coils in the spiral forming each infundibulum. The specimen measures 9 mm. in breadth by 6·5 mm. in length.

EXPLANATION OF THE PLATES.

The objectives employed while drawing the figures were as follows :—

Swift, 1 inch—magnifies about		45	diameters.
„ $\frac{1}{4}$ „	„	225	„
„ $\frac{1}{6}$ „	„	300	„
Hartnach, No.	4 „	50	„
„	5 „	180	„
„	7 „	330	„
Zeiss $\frac{1}{12}$, oil immersion	„	950	„

The following system of lettering has been adhered to in all the figures :—

at, atrial aperture.
br, branchial aperture.
br.f, fold in branchial sac.
c, enlarged end of tubule of intestinal gland.
d, duct of intestinal gland.
d.l, dorsal lamina.
d.t, dorsal tubercle.
en, endostyle.
g, genital mass.
gl, gland at pylorus of stomach.
g.c, nerve cells in outer part of ganglion.
h, heart.

h.m, horizontal membrane of branchial sac.
i, intestine.
i.l, internal longitudinal bar of branchial sac.
l, lobe at branchial aperture.
l.v, fine longitudinal vessel of branchial sac.
m^1 to m^8, the muscle bands in *Doliolum*.
mb, membrane.
m.b, muscular bundle.
mh, mesh of branchial sac.
n, *n'*, nerves.
n.a, aperture of duct from neural gland.
n.d, duct from neural gland.
n.g, nerve ganglion.
œ, œsophagus.
œ.a, œsophageal aperture.
ov, ovary.
p, papilla; *p'*, smaller intermediate papilla.
p.p, peripharyngeal band.
sg, stigmata.
st, stomach.
t, testis; *t'*, anterior prolongation of testis.
tn, *tn'*, *tn''*, tentacles of 1st, 2nd, and 3rd order.
tr, transverse vessel; *tr'*, *tr''*, smaller transverse vessels.
v.d, vas deferens.
z, prebranchial zone.

Plate XVI.

Ascidia tritonis, n. sp.

Fig. 1.—*Ascidia tritonis*, seen from the right side. Natural size.
Fig. 2.—A small portion of the surface of the test. Slightly magnified.
Fig. 3.—Another specimen, after the removal of the test, seen from the left side. Natural size.
Fig. 4.—Part of the branchial sac, from the inside. Objective, Swift, 1 inch.
Fig. 5.—Small portion of dorsal lamina, showing free edge. Objective, Swift, 1 inch.
Fig. 6.—Dorsal part of anterior end of branchial sac, showing tentacles, dorsal tubercle, peripharyngeal bands, &c. Objective, Swift, 1 inch.

Plate XVII.

Figs. 1 and 2, *Ciona intestinalis*, Linn. Figs. 3 and 4, *Ascidia virginea*, O. F. Müller. Figs. 5 and 6, *Polycarpa pomaria*, Sav.

Fig. 1.—A small portion of the branchial sac of *Ciona intestinalis*, Linn., seen from the inside; papillæ not represented. Objective, Swift, 1 inch.
Fig. 2.—Another small portion of the branchial sac of *Ciona intestinalis*, from the inside. Objective, Swift, 1 inch.
Fig. 3.—*Ascidia virginea*, O. F. Müller, var. *pedunculata*, from the left side. Natural size.

Fig. 4.—Dorsal part of anterior end of branchial sac of *Ascidia virginea* var. *pedunculata*, showing tentacles, dorsal tubercle, &c. Objective Swift, 1 inch.

Fig. 5.—*Polycarpa pomaria*, Savigny, seen from the left side. Natural size.

Fig. 6.—Part of the branchial sac of *Polycarpa pomaria*, seen from the inside, and showing two folds and two interspaces. Objective, Swift, 1 inch.

Plate XVIII.

Doliolum denticulatum, Quoy and Gaimard.

Fig. 1.—*Doliolum denticulatum* from the right side. Natural size.

Fig. 2.—A specimen preserved in chromic acid and absolute alcohol, from the left side. Natural size.

Fig. 3.—The same specimen seen from the ventral surface.

Fig. 4.—A young individual (2 mm. in length) seen from the right side. Objective, Hart. 4.

Fig. 5.—Part of a muscle band from the mantle of a specimen preserved in picric acid. Objective, Hart. 5.

Fig. 6.—Another muscle band from the same specimen. Objective, Hart. 5.

Fig. 7.—Anterior half of endostyle, seen from the interior of the branchial sac, from specimen stained in picro-carmine. Objective, Hart. 4.

Fig. 8.—Nerve ganglion, dorsal part of peripharyngeal band, &c., seen from interior of branchial sac. Objective, Hart. 4.

Fig. 9.—Broad barrel-like form of *Doliolum denticulatum*, from left side. Natural size.

Fig. 10.—Two specimens of the narrow elongated form. Natural size.

Fig. 11.—Right side of branchial sac, &c., from interior. Reduced from Objective, Hart. 4.

Fig. 12.—Nerve ganglion, neural duct, peripharyngeal band, &c. Objective, Hart. 5.

Fig. 13.—Small part of peripharyngeal band, from specimen stained in osmic acid. Objective, Hart. 7.

Plate XIX.

Doliolum denticulatum, Quoy and Gaimard.

Fig. 1.—Nerve ganglion and dorsal part of peripharyngeal band, from a specimen preserved in chromic acid and absolute alcohol, and stained in picro-carmine. Objective, Hart. 4.

Fig. 2.—The ends of some of the stigmata, from a specimen preserved in picric acid. Objective, Swift, $\frac{1}{4}$ inch.

Fig. 3.—Some of the ciliated cells bounding the stigmata, stained in picrocarmine. Objective, Hart. 7.

Fig. 4.—Some of the ciliated cells bounding the stigmata, stained with osmic acid. Objective, Zeiss, $\frac{1}{12}$, oil immersion.

Fig. 5.—Some of the cells from the surface of the peripharyngeal band of a specimen preserved in chromic acid, and stained in picro-carmine. Objective, Zeiss, $\frac{1}{12}$, oil immersion.

Fig. 6.—Part of the prebranchial zone in a specimen preserved in osmic acid and absolute alcohol. Objective, Hart. 7.

Fig. 7.—Part of the prebranchial zone enclosed by the coiled dorsal ends of the peripharyngeal band, from a specimen preserved in chromic acid and absolute alcohol, and stained in picro-carmine. Objective, Zeiss, $\frac{1}{12}$, oil immersion.

Fig. 8.—The anterior half of the nerve ganglion, showing the origin of the neural duct, from specimen stained in osmic acid. Objective, Zeiss, $\frac{1}{12}$, oil immersion.

Fig. 9.—Anterior end of the duct from the neural gland, showing its ciliated expansion and terminal aperture, from specimen preserved in osmic acid and absolute alcohol. Objective, Zeiss, $\frac{1}{12}$, oil immersion.

Fig. 10.—Posterior end of endostyle, œsophageal aperture, and the neighbouring part of the branchial sac, seen from the interior, from a specimen preserved in chromic acid and absolute alcohol, and stained in picro-carmine. Objective, Hart. 4.

Fig. 11.—Part of the heart, from specimen shown in fig. 10. Objective, Hart. 7.

Fig. 12.—Part of the ganglion, showing the origin of one of the nerves, from a specimen preserved in picric acid and absolute alcohol, and stained in picro-carmine. Objective, Zeiss, $\frac{1}{12}$, oil immersion.

Fig. 13.—A group of nerve cells from the ganglion shown in figure 12. Enlarged from Zeiss, Objective $\frac{1}{12}$, oil immersion, ocular 4.

Plate XX.

Doliolum denticulatum, Quoy and Gaimard.

Fig. 1.—Œsophagus, stomach, intestine, digestive glands, reproductive organs, &c., of an individual preserved in alcohol, and stained in picro-carmine. Reduced from Objective, Swift, 1 inch.

Fig. 2.—Part of the duct (*d*) crossing from intestine to stomach in last figure. Objective, Zeiss, $\frac{1}{12}$, oil immersion.

Fig. 3.—Part of the digestive gland forming a network of tubules over the intestine, from same specimen as fig. 1. Objective, Swift, $\frac{1}{6}$ inch.

Fig. 4.—Part of the wall of the intestine, surface view. Objective, Hart. 5.

Fig. 5.—Part of the organ (*gl*) seen ramifying over the stomach and first portion of the intestine in fig. 1, from specimen stained in picro-carmine. Objective, Zeiss, $\frac{1}{12}$, oil immersion.

Fig. 6.—The reproductive system dissected out. Reduced from Objective, Swift, 1 inch.

Fig. 7.—The same in another specimen, showing a curious anterior termination. Reduced from Objective, Swift, 1 inch.

Fig. 8.—Anterior extremity of the testis of another individual, stained in picro-carmine. Objective, Swift, 1 inch.

Fig. 9.—Anterior extremity of the testis in another specimen, preserved in solution of osmic acid. Objective, Hart. 5.

Fig. 10.—Anterior extremity of the testis in another specimen, stained in picro-carmine. Objective, Swift, 1 inch.

Fig. 11.—Anterior extremity of the testis in another specimen. Objective, Hart. 5.

Fig. 12.—Small part of the edge of the testis near the posterior end. Objective, Hart. 7.

Fig. 13.—Opening of vas deferens close to ovary. Objective, Hart. 4.

Fig. 14.—Aperture of vas deferens. Objective, Hart. 7.

Fig. 3.

Fig. 2.

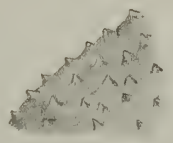
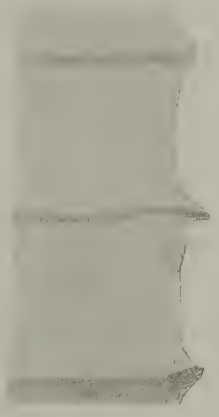


Fig. 1.

Fig. 5.



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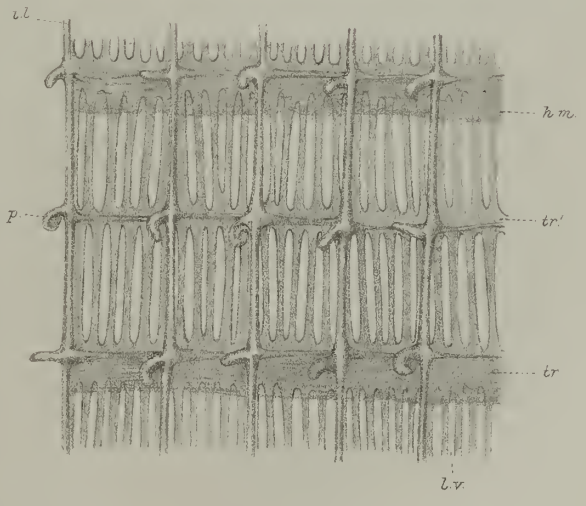

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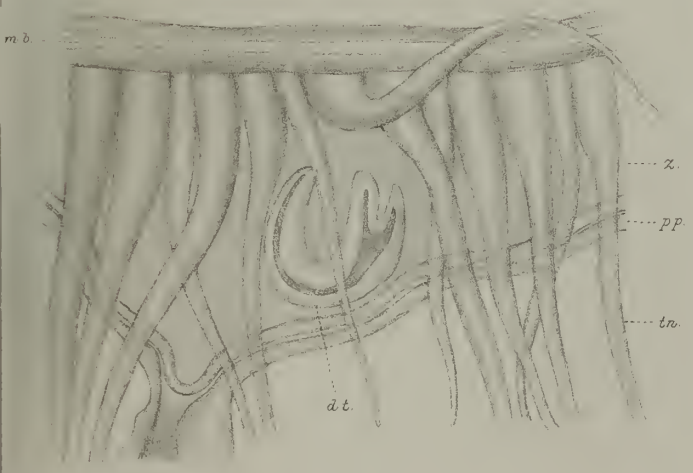

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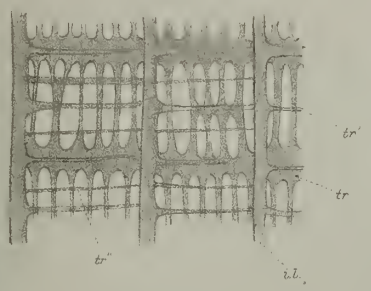
F. Huth, Lith.ᵍ Edin.ᵍ

ASCIDIA TRITONIS, n. sp.

Fig. 1.



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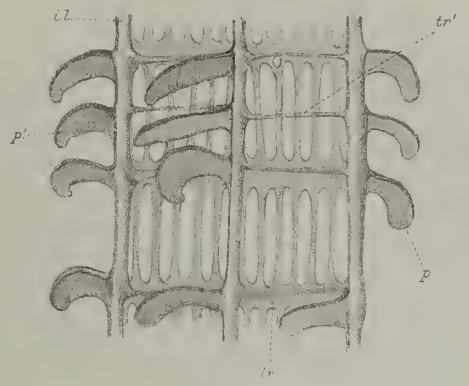

Fig. 3.

Fig. 4.

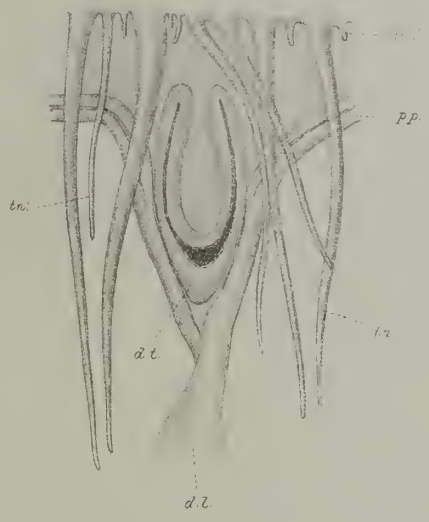

Fig. 6.

Fig. 5.

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FIG^s 1 & 2 CIONA INTESTINALIS, Linn. FIG^s 3 & 4 ASCIDIA VIRGINEA var. PEDUNCULATA.
FIG^s 5 & 6 POLYCARPA POMARIA, Sav

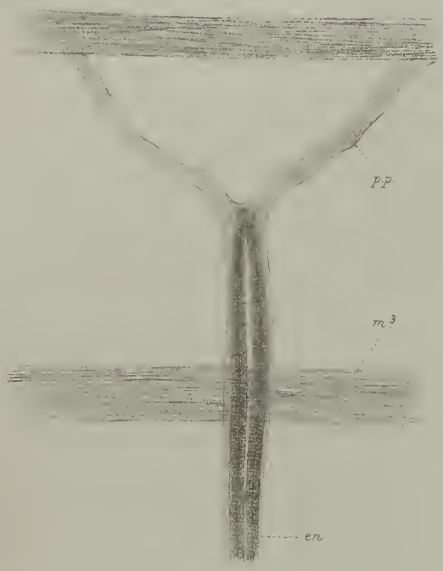
Fig. 3

Fig. 2.

Fig. 1.

Fig. 4.

Fig. 7.



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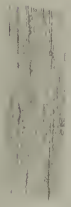

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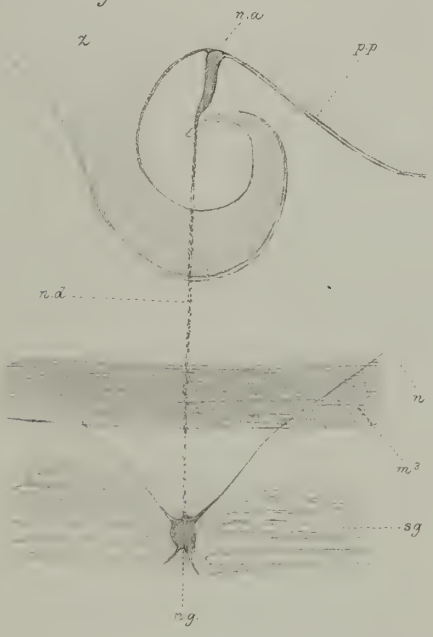
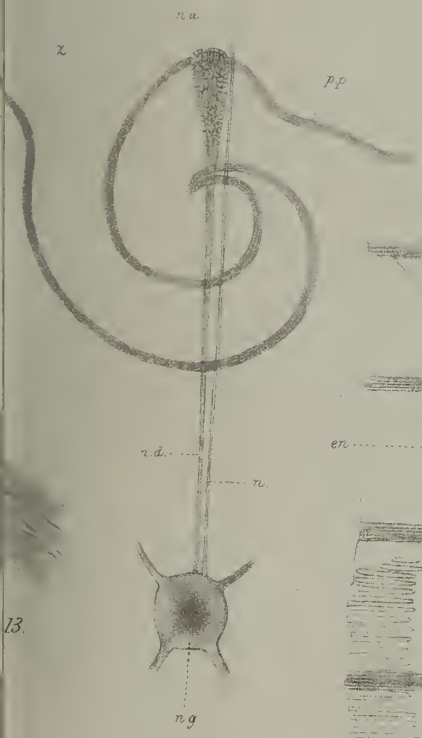


Fig. 9

Fig. 10.

Fig. 12.



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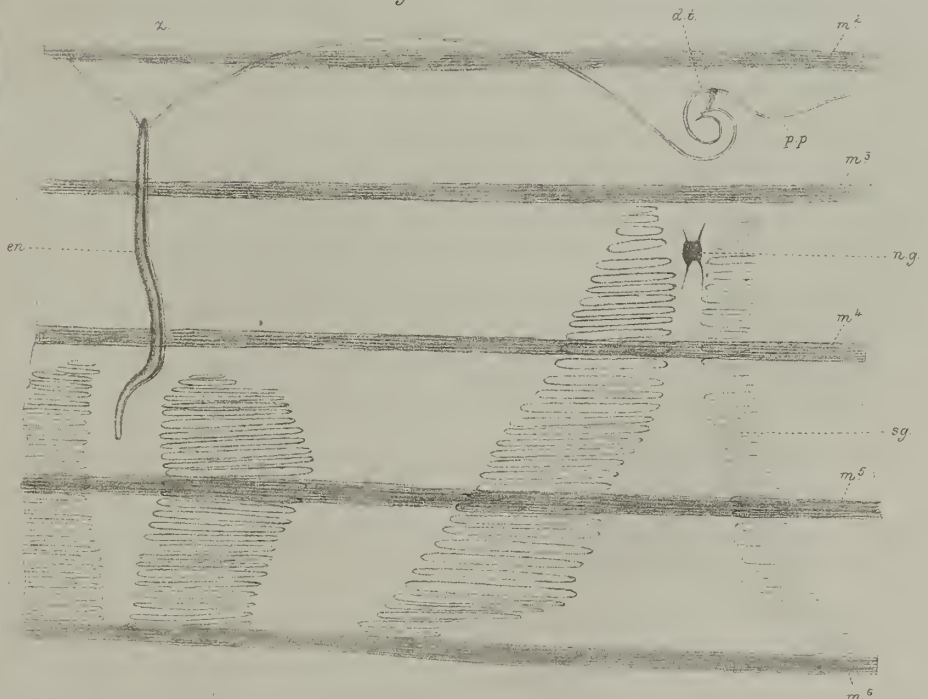

13.

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F Huth, Lith^r Edin^r

DOLIOLUM DENTICULATUM, Q & G.

Fig. 1.

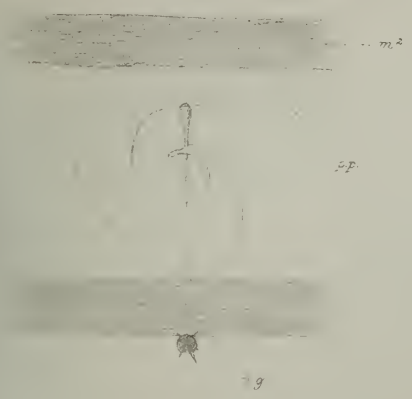


Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 10.

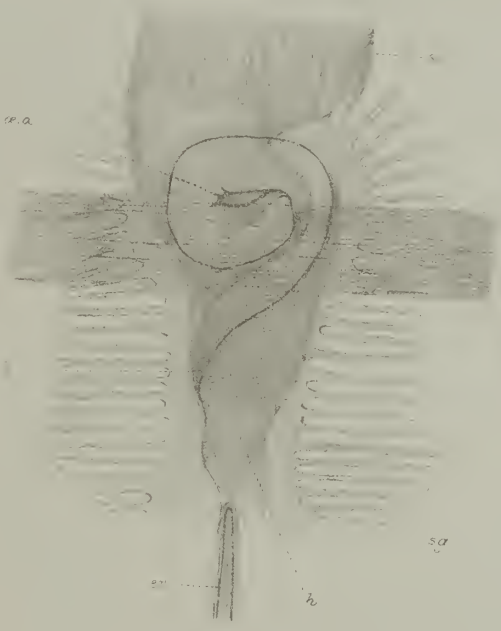
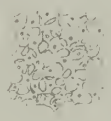


Fig. 9.

Fig. 6.



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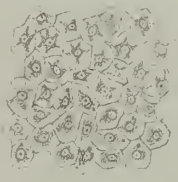

Fig. 11.

Fig. 8.

Fig. 12.

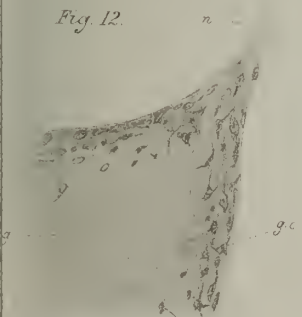

Fig. 13.

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DOLIOLUM DENTICULATUM, Q. & G.

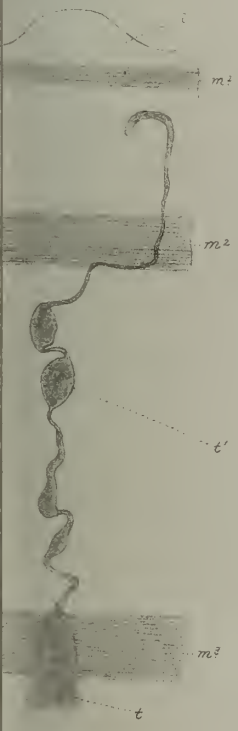
Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4

Fig. 8.



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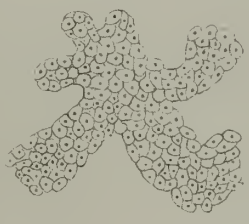


Fig. 14.

Fig. 7.

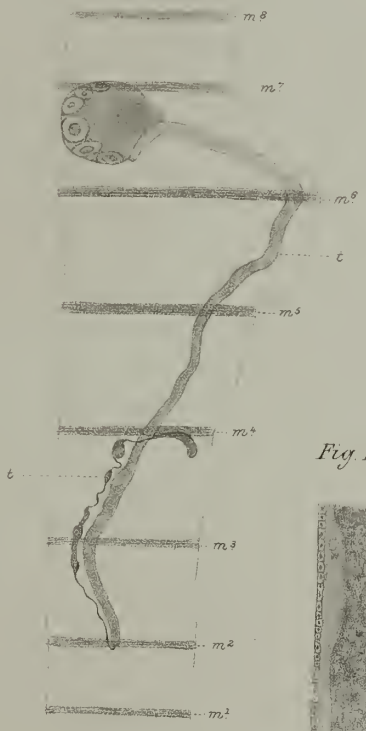
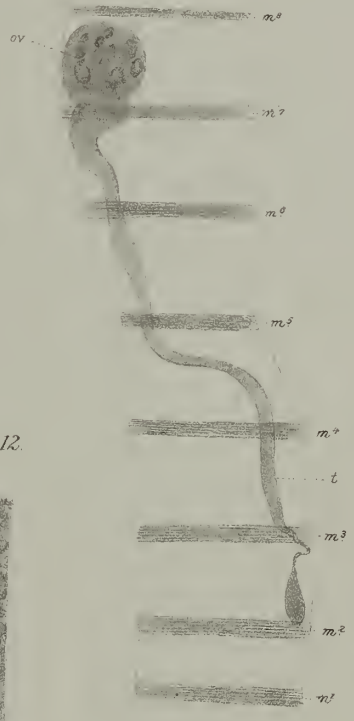


Fig. 12.

Fig. 6.



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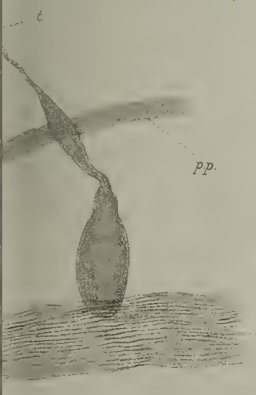

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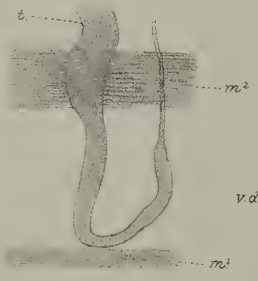

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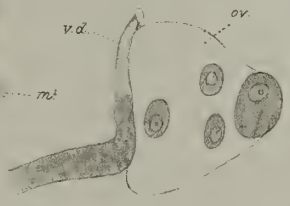

Fig. 11.

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DOLIOLUM DENTICULATUM, Q. & G.